

This paper was originally published in: NATO Advanced Study Institute on Computer Communication Networks, University of Sussex, held in 1973. Proceedings were published by Noordhoff - Leyden in 1975.

A SURVEY OF PRESENT AND PLANNED GENERAL PURPOSE EUROPEAN DATA AND COMPUTER NETWORKS

Peter T. Kirstein University of London

Packet networks mentioned:

[CTNE RETD](#)

[EPSS \(UK GPO\)](#)

[RCP \(French PTT\)](#)

[CYCLADES](#)

[SITA](#)

[EIN \(nee COST\)](#)

[General Electric](#)

[TYMNET](#)

1. INTRODUCTION

In this paper we give a brief overview of the special data networks which have been announced in Europe. First two special line switched, networks are discussed. ([ref 2](#)), which are already operational. The first, the French Caducee, uses modems; the second, the German EDS, so far is handling only experimental telex traffic, but will soon go on line at higher speeds. The present generation of data networks is being developed slowly on only an experimental scale, because it is universally realised that synchronous networks with digital transmission are the way to go in the future. Because of the need. to interwork internationally, careful attention is being paid to common standards on such networks. So far the most of the telecommunications authorities have only been convinced to provide line-switched services, and some of the plans in this area are described in [ref 3](#). Two European countries, Spain and the UK, are definitely providing packet switched services - at least on an experimental scale. These activities are discussed in [ref 4](#).

So far the discussion has been restricted to data networks - irrespective of the terminals or computers to be attached to them. A few distributed computer networks have started to be developed amongst similar machines. Two of these, one French and one British, are discussed in [ref 5](#). These networks have started to address the problems which arise when one tries to use computers in the network environment.

Many restricted use data networks have been set up to widen the catchment area for particular large hosts - the banks have many examples of this type of network. Comparatively few of these networks use packet switching, or are designed to link a heterogeneous set of computers and terminals. Two networks which have these properties, one for airlines and one for banks, are considered briefly in [ref 6](#). The European heterogeneous general use networks are only being designed at this time. Two such networks, one French and one European, are mentioned in [ref 7](#). Fuller details of these networks are given in other papers at this symposium, but they are mentioned here to round off the picture.

On the whole this paper has dealt with European developments. There are many papers here on different aspects of ARPANET. However no mention is

made of other highly reliable commercial networks in the US. Because a comparison of the technologies of these networks with other described here is important, two commercial US time-sharing networks are discussed in [ref 8](#).

Finally, an attempt is made in [ref 9](#) to draw some conclusions from this rather patchy overview of the European scene. It is clear that for some time to come the development of data networks and ad hoc computer networks will develop in parallel. To what extent the data networks being developed by the PTTs will meet the network needs of users is of considerable interest to all at this symposium.

2. PRESENT LINE SWITCHED DATA NETWORKS

Two countries, France and W. Germany, have started introducing special line-switched data networks.

The French have introduced the Caducee system, sketched in Fig.1. This system is based on an Erikson CP 410 crossbar switch. It is a circuit switched system for the speed range 2400-72K bps using analogue transmission. The system is based on 2000 line exchanges as sketched below:

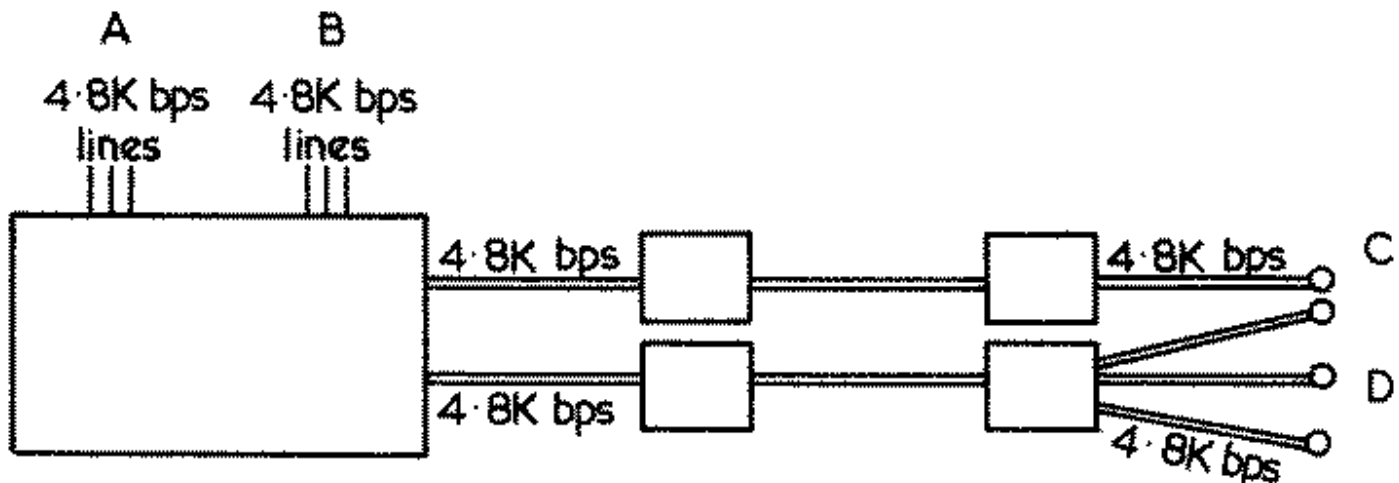


Fig. 1 Schematic of French CADUCEE

There are four classes of subscribers:

- A. Those within 30 km of an exchange using ordinary modems
- B. Those within 30 km of an exchange using a base-band modem
- C. Those at larger distances from an exchange with heavy traffic using ordinary modems.
- D. Those at larger distances from an exchange with less traffic, connected to it through a concentrator, again via ordinary modems >

Although any modems can be connected, the French PTT will supply modems at 2.4K bps and later 4.8K bps for Classes A, C and D, and a modem at 19.2K bps for B. Later they hope to provide higher speed modems. The same quality of four-wire lines will be used as for leased telephone service. Call set-

up time is six seconds, and there is out-of-band signalling via a touch-tone telephone. A typical configuration is shown in Fig. 2.

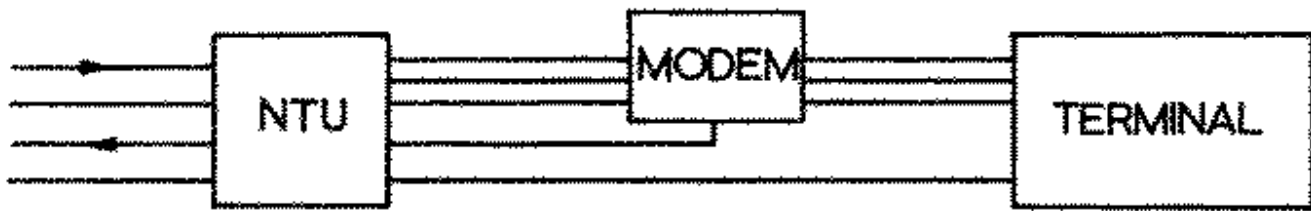


Fig. 2 Schematic of Caducee network Terminal Unit Attachment

The NTU has a telephone, twelve push buttons for signalling, and six lights (intervention, out of order, busy, indication to dial, transmission in progress, and free), and eight buttons (make busy, manual call, manual intervention, automatic call, free line, register intervention, clear intervention register).

Each Caducee exchange can handle about 2K duplex circuits;

1600 are ordinary lines, 240 lines with remote concentrators for calling in, 240 with remote concentrators for calling out. The concentrators concentrate forty channels onto twenty lines, and are envisaged for circuits with 0.2 erlang traffic or less. Initially there is one exchange, but as needs grow additional exchanges will be installed initially in remote towns. Added stations will increase the area over which high speed traffic is possible. The first Caducee exchange became operational in early 1972.

A far more ambitious system, the EDS system is being developed by Siemens for the German Post Office. A fairly complete description in English is now available [1,2](#).

The system has been discussed, in the references, so will not be described in detail here. The important point is that the system is essentially asynchronous. Schematically it is shown in Fig.3.

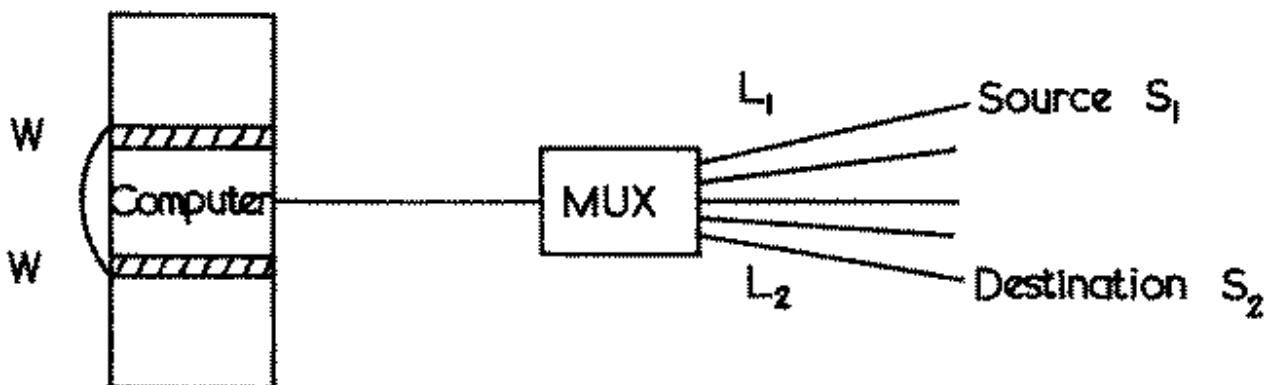


Fig. 3. Schematic of EDS exchange

A computer is attached to up to 13K lines by a special multiplexor. To each line there is allocated a word in core W. Any data input from L will

affect W. Making a connection from a terminal S_1 to S_2 would be accomplished by setting a pointer in W_1 to W_2 and vice versa. Once a connection has been made, the MUX will detect any change in state of the bistable line L_1 . If a number of lines change state simultaneously, since the computer can service only one line at a time, there will be a delay in some of the changes being passed on; this delay will show up as distortion in the transmitted signal. Provided this distortion is not too serious there will be almost complete transparency in data speed or format with this network. I say almost complete transparency, because signalling to make a connection will be at a specific speed with ISO Alphabet No.5. While the connect time is designed to be 100 ms, the time to terminate a call may take 250 ms, or 300 ms if remote concentrators are used.

The main purpose of this system was initially to take over the 50 bps telex and the 200 bps telex (the DATEX system). Typical numbers of lines active on a 13K line exchange envisioned by Siemens in early studies are shown in Table 1:

Class	Speed K bpr	Signalling Rate K bps	No. of Active Connections	% of Machine Cycles
1	<.85	.05	4300	13
2	.050<S<.2	.2	375	5
3	.2<S<2.4	2.4	275	39
4	2.4<S<9.6	2.4	75	43

Table 1: Speeds and Signalling Speeds of Different Classes

Clearly a small proportion of higher speed, traffic would saturate this system. The Germany PTT has stated, that for the time being it will only use this system asynchronously for classes 1 and 2 up to 200 bps. Above that speed. Siemens is now developing synchronous units. It seems clear that the growth of the EDS system will be in accordance with the other networks of [ref 3](#).

Siemens claim that when the EDS exchange is working synchronously, its throughput is much higher than indicated in Table 1. When it is equipped with a 200 ns memory and a single set of buffers it can handle the following traffic:

Speed (K bps)	0.6	2.4	9.6	48
No. of full duplex connections	25K	6.2K	1.56K	312

Table 2: Capacity of EDS exchange for Synchronous traffic

However the time to set up calls is comparatively long - 20ms, Thus at most 50 calls/sec could, be set up. This implies that the EDS system is not ideal for short transactions. For comparison, in the packet switching ARPANET IMP⁴ it would, be possible to generate an order of magnitude more short messages to different sites.

In the EDS system there will also be a remote controlled, concentrator, with 10 lines to the exchange and 100 to subscribers. It will have facilities for abbreviated dialling, multi-address messages, calling station identification and closed user groups. Facilities for packet switching, hot-line and delayed delivery have been announced on the EDS exchange by Siemens, but the German. PTT have not said. that they will provide these facilities. A prototype exchange is being operated in Munich, and the first real exchange is scheduled for 1974. Some ten exchanges are scheduled by 1976.

3. SYNCHRONOUS DATA NETWORKS

Many of the wide spread computer networks have implemented a communication subsystem, which operates over the analogue telephone network. Some of these subsystems are described briefly in this paper. For some years the international body called "Committee Consultative Internationale de Telegraphe et Telephone" (CCITT) has studied the requirements for specialised data networks in their working party on New Data Networks (NRD). The CCITT is a consultative committee to the International Telecommunications Union, and its recommendations are usually followed by the national telecommunications administrations (PTTs).

The NRD has concluded that it is the declared intention by a number of PTTs to provide data services over synchronous networks⁵. At the moment the only facilities which will be provided by most such countries are for circuit-switched connections, in which a single channel is provided between two terminals. On the present analogue public switched telephone network, full duplex facilities are usually provided only up to 200 or 300 bps, with half-duplex facilities up to 1200 or 2000 bps. The New Networks will use PCM digital transmission, and plan to provide a number of user classes with full duplex capability as indicated in Table 3. The new networks are planned for introduction between 1975 (US) and 1985, with many starting about 1980. For this reason it is felt that a little information about these networks is of some importance. Further details are given elsewhere^{6,7}

Class	User data class of	Address Selection and Service Signals (Alphabet No. 5)
1	200 bps, 11 units/char start/stop	200 bps
2	200 bps, 50-200 bps, 7.5-12 units/char start/stop	200 bps
3	600 bps synchronous	600 bps
4	2400 bps synchronous	2400 bps
5	9600 bps synchronous	9600 bps
6	48000 bps synchronous	48000 bps

Table 3: Classes of user Services Recommended

Certain specific recommendations have been made on class 2, so that the combinations of speed and units/character match present terminals.

It is proposed that these new data networks have a public switched capability of making a call "reasonably fast"; however the present set of recommendations do not seem to guarantee such a call being set up in less than 10 secs, or shut down in less than 1 sec. It is supposed to be symmetrically duplex, bit sequence independent, with automatic calling and answering. It is recommended that direct call, abbreviated address and closed user groups be provided. Remote terminal identification, multi-address, and delayed delivery for class 1 service may be provided.

The actual transmission between exchanges will be at a multiple of 64K bps (usually 2.048 M bps in Europe which uses 32 64K bps channels). It will usually share the same long distance transmission as the telephone system, but use different exchanges. It will use different terminating units to subscribers' premises from the present modems. In many countries the new network is intended to carry the telex traffic, and possibly also facsimile.

There are a number of consequences of the need for inter-working between countries, together with facilities for complete bit transparency⁵. Several countries (particularly AT&T and Canada) have opted for wishing to have a frame consisting of some synchronising or control bytes followed by data bytes:

SYN data data data ... SYN data data data SYN

Others have preferred to have each byte carry information on whether it is control or data e.g.:

Bit	1	2-7	8
Content	Frame	Information	Status

Table 4: Frame Format for synchronous Data

Here for one value of status the information is data, for another control. Denmark, Finland, W. Germany, Norway, Sweden and the UK have opted for this system; France and Italy have said they would use both methods. The two systems will be kept capable of interworking, because it has been agreed to use a 32 bit frame consisting of four 8 bit bytes. In the first scheme there will be one control byte followed by three data bytes/frame; in the second each frame will have four bytes of which again up to 24 bits are data.

Since the control and framing information is put in by the switching exchanges, the relative transmission rates in the classes are shown below:

Class	1	2	3	4	5	6
Rate bps	266	266	800	3,200	12,800	64,000

Repetition in 64K bps stream	240	240	80	20	5	1
---------------------------------	-----	-----	----	----	---	---

Table 5: Signalling speeds and number of bytes in 64K bps channel for data for a signal user class

The typical schematic of a system of this sort is indicated below:

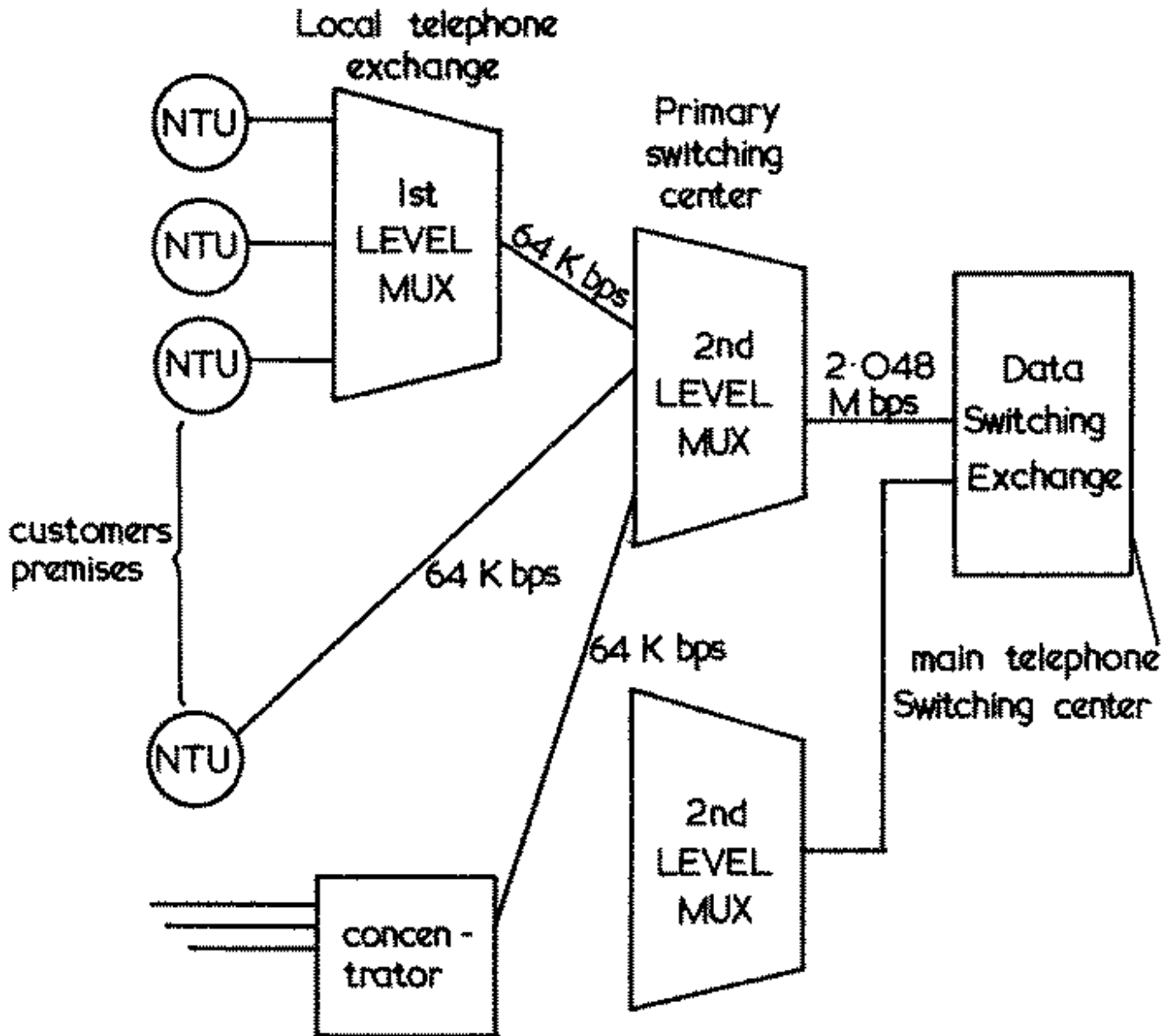


Fig.4: Schematic of Data Network Multiplexing

It would, be possible to add packet switching to such a system, but the NRD has not made any recommendations on this point.

The UK BPO⁷ claimed that while most of the traffic in a network can be best handled by circuit switched techniques, others can be handled better by breaking up the data into packets; these are then sent by fairly

standard store and forward techniques. They claimed that a DSE built to handle packets would be only 15% more than one without, and the DSE costs are only 25% of the network. At that time (1971) they aimed at an installed capital cost of switch of \$600/line. [preceding currency symbol unclear: RDM] A schematic of the DSE for mixed packet and circuit switching is shown in Fig.5.

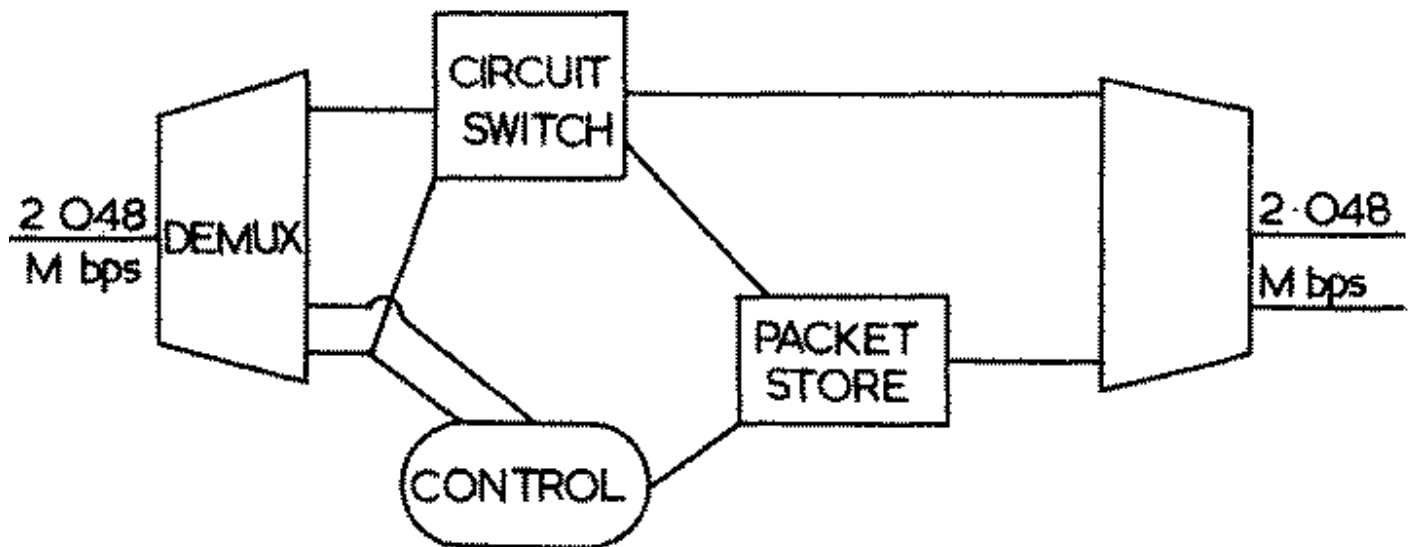


Fig.5: Schematic of Packet and Circuit Switched Operation in the Data Switching Exchange (DSE)

The above is an example of how packet switching could be added to synchronous line-switched networks. No European PTT has committed themselves to provide such a service, however.

The PTTs of a number of countries have announced definite plans to introduce trial networks of this kind (without packet working). Amongst these are Norway⁸ and Sweden⁶. Both of these two will have three nodes. The Norwegian one will have initially 72K bps transmission between nodes at Oslo, Trondheim and Bergen. At each city there will be a 512 port multiplexor to subscribers' equipment, and between the subscriber and the multiplexor analogue transmission via modems will be used. There will be initially only leased line service in 1974> and switching may be added later.

The Swedish system (also to commence in 1974) is somewhat more ambitious. It will have a switching exchange in Stockholm, attached by 42K bps lines to concentrators in Stockholm, Malmo, and Gothen-berg. It will have limited capacity, initially for only 100 terminals of different types. Transmission speeds of 2.4K bps will be offered, initially, with 9.6K bps and 600 bps following later; the customer interface will be as for synchronous modems. This system will use something like the CCITT envelope scheme, and have a call set-up time of 100-200 ms. France and the UK⁷ are studying larger networks (the UK with capacity for 50K terminals), and W. Germany⁹ is looking at transforming its EDS network into a synchronous one.

4. PUBLIC PACKET SWITCHED NETWORKS

Only the Spanish PTT has declared itself for packet switched working¹⁰.

However both the UK¹¹ and France¹² decided to introduce experimental services. All these networks use (or will use) analogue transmission via modems at this time.

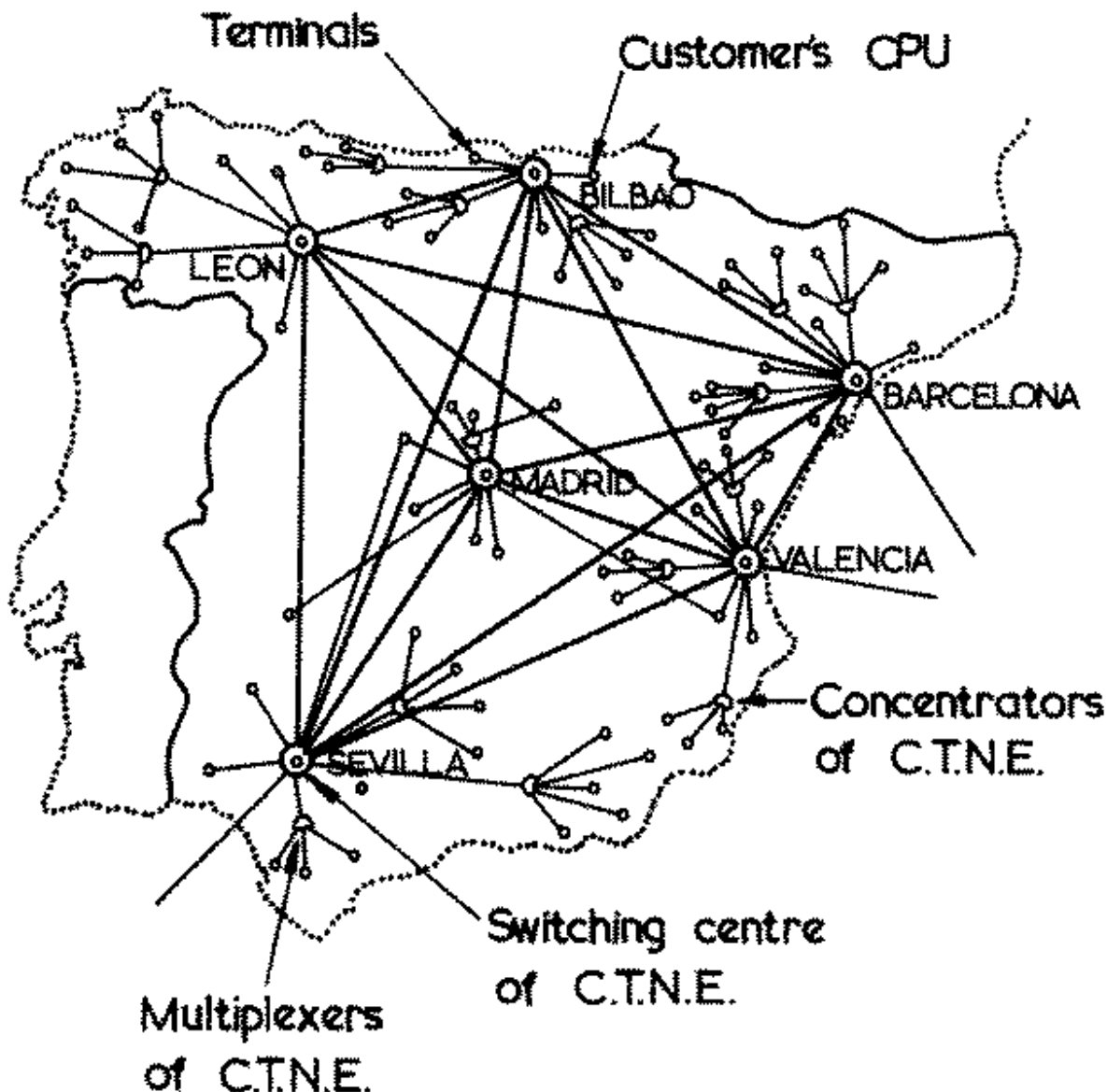


Fig. 6: Schematic of Spanish CTNE packet switched Network

The Spanish system is directed at multiplexing terminal traffic to real-time computers. It is based currently on duplexed Univac 418 computers as switches (DSE) at Madrid, Barcelona and Seville, though a fourth will be installed at Valencia before the summer of 1974. The configuration planned by 1978 is shown in Fig. 6. A high-level packet-switched network connects the main switching centres at 48K bps. To these switching centres can be attached customers computers (TA), multiplexors (M), concentrators (C), or customers terminals (T). At the moment three computers, with 150 terminals are attached. The system permits both virtual circuits to be set-up, and to have each packet containing its own header. Terminals are attached to the multiplexors M or concentrators C initially at 200 bps, 600 bps or 1200 bps. The M and G are themselves attached to the DSE initially at 4.8K bps; I presume the computers are attached to the DSE currently at the same speeds. Already the Spanish experience with their switches has caused them

to modify their line handling hardware and software.

The British experimental service is being described in considerable detail at this symposium. It is again initially based on three DSEs at London, Manchester and Glasgow - connected to each other by several 48K bps lines. Packet-based connection to the DSEs is at 2.4 or 48K bps; start-stop access from terminals is at up to 300 bps. The DSEs are capable of handling up to 24 packet type of terminals each. The first node is scheduled for operation in early 1975 with the other two following within the following six months.

The French plans are more modest. They again will have three DSEs (PDP 11/20s), sited at Paris, Rennes and Lyons. These are scheduled to be working internally by the end of 1973 with a public service in 1974. The connection between the DSEs will be only at 2.4K bps, but the total instantaneous rate of traffic to a DSE can attain tens of K bps on up to 200 lines. One of the aims of the system is to investigate what occurs when the DSE becomes over-loaded. The terminal access can be at up to 9.6K bps in a burst mode, but clearly such rates could not be sustained.

All the three services mentioned above are essentially packet-switched data networks. They are designed to handle the idiosyncrasies of certain types of terminals - but it is not clear how far the PTTs will go even in that regard. The PTTs certainly do not regard the procedures for handling computer-computer connections to be part of their brief.

5. HOMOGENEOUS PACKED SWITCHED COMPUTER NETWORKS

Two packet switched computer networks based on homogeneous computers deserve mention. In one, a number of IBM computers in France are linked by 4.8K bps lines without a communication subnetwork¹³. Although all the computers involved are IBM 360s, they do run different versions of the operating system. The computers in the network are the 360/91 at Saclay, the 360/75 at CRNS, the 360/67 at Grenoble U, the 360/50 at IBM Paris, and the 360/40 at Ecole de Mines and IBM Grenoble. Beside the store and forward operation, facilities existed, by the middle of 1972, for interactive use of the remote computer and the transfer of whole files, and remote job initiation.

In much the same category is the network of the UK South West universities¹⁴. In this network four ICL System 4 computers (at Bristol U, Cardiff U, Exeter U and Bath U) are attached to a CDC 1700, which acts as a communication switcher, by 48K bps lines. Here again any terminal on one system computer can have interactive access to programs in another, and it is possible to transfer files and submit jobs. In this network virtual circuits, rather than packets, are sent. There is a Network File System, and the communication computer also keeps a catalogue of all the files in the network. It is intended to permit automatic off-loading of restricted classes of jobs from one system to another. At the moment this is only possible if its jobs require no files.

6. RESTRICTED USER CLASSES OF PACKET-SWITCHED DATA NETWORKS

Two packet switched networks are in a special category. They are international data networks but intended for a particular user community.

The SITA network is a store and forward message switching network for airlines with DSEs in London, Amsterdam, Brussels, Frankfurt, Rome, Madrid, Paris and New York. It is over-connected, and consists of Univac 418 and Philips DS 714 computers. There are remote concentrators (mainly Raytheon 706) attached to the DSEs; many of the airlines connect their terminals to the DSEs via the remote concentrators. Most of the traffic on the network is terminal based message traffic, but several airlines have tied their computers directly to the DSEs with medium speed lines. Typical responses to messages in the network are 6 secs; the message length has been carefully chosen to meet the average message length of 180 chars.

The Banks are setting up the SWIFT message switching system for inter-bank transfers. This system will have initially the switching centres in Brussels and Amsterdam, and concentrators in eleven countries. It will handle a number of terminals including keyboard, terminals, magnetic tape units, minicomputers controlling clusters of terminals, and the front-end, computers of the Banking System computers. Few details have been released yet, but it is expected to start operation in 1975. Opposition from the US record carriers, who have a monopoly at this time of US-international data traffic, has so far prevented approval for the SWIFT system to be extended to the US.

7. GENERAL USE HETEROGENEOUS COMPUTER NETWORKS

The only European packet-switched system actually operational is the one internal to the National Physical Laboratory¹⁵. This system was conceived about the same time as ARPANET, and uses already digital transmission. It connects a number of host computers and terminals through a single packet switching exchange, and is therefore like one node of a system like the EPSS.

Two heterogeneous computer networks of different types are being developed. The aim of both systems is to access data bases on computers attached to one DSE from terminals attached to computers on another DSE. Both are discussed in details at this conference, and so will only be mentioned briefly here.

In CYCLADES¹⁶, the French are developing the first general purpose heterogeneous computer network in Europe. At the moment its DSEs, which are MITRA 15 computers, are stated to have connections only to Host computers. It is planned to have five DSEs, in Grenoble, Paris, Rocquencourt, Rennes and Toulouse. The DSEs will be connected by 48 or 4.8K bps lines; some 16 hosts will be connected to the DSEs with lines at speeds varying between 4.8 and 48K bps. The communication between the DSEs and between the DSEs and Hosts are packet based. The network is being developed by computer specialists, so that the higher level protocols between the operating systems of the Hosts are of considerable concern.

This is also one of the first networks in which the problem of connecting different networks is being considered. The Hosts planned for attachment include CDC 6000, IBM 360, CII 10040, IRIS 80 and Philips P1100 computers, so that the network will be truly heterogeneous. The first DSE is now operational, and the first Hosts will be attached in 1974. The system is expected to be operational in 1975.

The second similar network being designed is the inter-European COST 11

one¹⁷. Here DSEs will be sited at London, Paris,

Zurich, Ispra and Milan. The specifications have just been completed for the DSEs, so that one may expect the communication subsystem complete in 1975, with Hosts attached by 1976. The applications to be made of, and Hosts to be attached to, this network are still not settled.

The US ARPANET chose to attach some DSEs which handled terminals as well as Host computers¹⁸. The main reason that such a development is not currently envisaged on CYCLADES and COST 11, is that terminal traffic is really the prerogative of the PTTs, who are developing their own networks. The development of these computer networks is proceeding in collaboration with the PTTs; one may expect either that DSEs with terminal handling facilities will be developed, for these networks, or that the National data networks will be attached in due course.

8. THE PROPERTIES OF TWO COMMERCIAL DATA NETWORKS

Two commercial US data networks are of interest in the context of ARPANET and the other networks which have been discussed in this paper. The first is the GE Time-sharing network, and the second Tymeshares' TYMNET.

The GE Time-sharing network, routes terminal traffic to a number of computer systems, which are currently located at one site. Previously the computer systems were at several sites, and the network design is not affected by the single location. A schematic of the GE Network is shown in Fig. 7. Here the central computers (CPU) are attached in pairs to the Central Concentrators (CC). These are themselves attached to a number of remote concentrators (RC), to each of which are attached a number of low speed terminal channels by a TDM or FDM multiplexed line. By arranging that, for example, the multiplexor terminals A and B in Fig.7 are in the same town, routes to a specific CPU may be found even if one RC, one CC and several lines were all faulty. It is possible to arrange that the rerouting of traffic is dynamic if equipment failures occur beyond the RC; if they occur between the RC and the subscriber, only a new local call need be made. In order to access other Hosts in the complex, all the CCs are connected to two switching computers. It is possible therefore to route traffic to any of the other computers in the network.

This type of topology has many similarities but many differences from ARPANET. It uses packet transmission from the RC up-stream, so that it makes the most of the long-line saving possible. It has a high reliability, and can be made to have high capacity. It uses virtual line switching to set up calls, and is therefore not very appropriate to short message traffic - but excellent for bursty time-sharing usage for which it was designed. Provided, the traffic is largely regional, so that only a small percentage passes through the switching computers SC, the capacity of the network is good. It is considerably more expensive, however, than the store and forward type of the ARPANET, which can use a smaller number of high speed line.

GEISCO & TYMSHARE structure



TYMSHARE uses a quite different technology of distributed control. Their system is more like ARPANET in some ways. A schematic of their topology is shown in Fig.8. Now each Host is fronted by a base switch (BS). There is also a store-and-forward network of remote switches (RS), which forward traffic from other BS or RS, and also concentrate terminal traffic. There are several different types of Hosts, and the TYMNET also acts as a data network to Hosts belonging to other organisations, who connect their host into a BS. Between the RS and RS or RS and BS data is sent in a block format. However in each block are sent a number of messages prefixed by two bytes - message length and channel number. When a terminal is logged on, a virtual circuit is established through the Network between the terminal and the Host. The RS nearest the terminal affixes the channel number. Each block sent can include a number of such messages. The RS (or BS) will then break up the blocks it receives and make up new ones related to the connections attached to it. This type of network requires one or more supervisors to set up the virtual circuits - i.e. assign the channel numbers. Usually only one supervisor is active, with others in a waiting state. If, however, the network becomes cut, from a number of faults or insufficient line redundancy, several hosts may act as supervisors.

Both the GE and TYMNET networks have local echoing at the nearest RS or BS. They also have techniques in each switch to limit the data flow which can be accepted from the terminals. Such techniques are necessary when faults occur in the store and forward network, or when the potential input from terminals becomes greater than the network can guarantee to accept. Both networks have much lower capacity lines, and therefore less capacity for high speed file-oriented traffic, than ARPANET. However both networks have a higher degree of over-connection, and greater reliability, than the present ARPANET.

There are some significant differences between the two networks. The GE one is clearly hierarchical, with powerful switches capable of taking a substantial number (several dozen) inputs and at least two outputs. The TYMNET is pretty homogeneous (with the exception of the BS). TYMNET is very distributed; the GE network has all intersystem traffic going through one of two special switches. Both have had to modify their switches for file transfer, and are catering for this by using large block sizes and faster switches with less ports.

9. CONCLUSIONS

In this survey we have described a variety of current European developments. Here we will summarise some of the trends which are emerging. The PTTs are developing synchronous line-switched digital data networks which shall be able to interwork internationally. These should make 4.8K bps available economically by 1980 in many countries. Most PTTs are not yet convinced on the need for packet switched systems, though some are starting experimental services. The results of these early services will clearly affect the rate at which packet switching is introduced. Internationally packet-based broadcast satellite transmission is interesting. Some PTTs are interested enough for them to wish to try experiments with it. Unlike the US, the monopoly position of the European PTTs make it difficult to get packet-switched services started in Europe until the PTTs are convinced about their desirability. For telex-like services they are already convinced, for data networks less so.

Some interesting information is coming from several homogeneous computer networks. Usually the homogeneity leads to the network procedures relying heavily on the properties of the existing operating systems. Some of the heterogeneous computer networks being implemented now attempt to avoid this pitfall. Most still are being developed without a clear need for them. A new generation of these networks is being planned because the need exists. These new computer networks may well be built around the generalised switched data networks developed - particularly in the UK, France and Germany.

Some of the commercial time-sharing networks have some lessons for the future computer networks. These networks while much simpler in concept than ARPANET have a better reliability and availability. This is due to careful engineering of the redundancy and duplication at all stages of the system. ARPANET has alternate routing only between IMPs; each Host is simply connected, for example, and few hosts are themselves duplicated with common file access. Some commercial time-sharing networks are duplicated right through the system.

It seems clear that there will still be many developments in reliability and simplicity in the networks. The new generations are starting to consider also the functions which should be carried out in the communication sub-network. This is leading to some significant deviations from the complete set of ARPANET protocols. We can be sure that the next decade will still be interesting in this field.

REFERENCES

1. Gabler, H.: The German EDS network, Proc 2nd Symposium on the Optimization of computer networks, 80, 1972.
2. Goslau, R. et al: EDS - A new electronic data switching system for data communications, Nachrichtentechn Z., 22, 444, 1969.
3. Pick, H. et al: Multiplexing and switching of data in synchronous networks and the realisation in the EDS-system, Proc. Int. Zurich Seminar on integrated sys. for speech. video and data communication, C5, 1972.
4. Heart, F. et al: The Interface Message Processor for the ARPA Computer network, Proc SJCC, 36, 551, 1970.
5. CCIT: Preliminary Report on the work of joint working party on "New Data Networks", GM/NRD No. 98. Geneva, 1972.
6. Larsson, T.: Data Communication in Sweden - and some aspects of the situation in Europe, Proc Inter. Conf on Computer Communications, Washington, 17, 1972.
7. Dell, F.R.E.: Features of a proposed synchronous data network, Proc 2nd symposium on the optimization of data networks. 50, 1972.
8. Bothner-By, H.: System Forslag et prevendatanett, Telektronikk. 1-2, 34, 1973.
9. Bocker, P. et al; Der aufbau von datennetzen mit dem elektronischen

datenvezmittlungssystem EDS, Nachrichtentechn Z., 26, 297, 1973.

10. - : General Description of the special network for data transmission and switching of C.T.N.E., C.T.N.E., 1971.
11. - : Experimental Packet Switched Services, Specification, BPO, 1973.
12. Depres, R.: La Commutation de Paquets dans un nouveau reseau de transmission de donnees, Proc. Int. Zurich seminar on integrated syst. for speech, video and data communication, 1972.
13. Girardi, S.: SOC Project; an experimental computer network, Proc. 2nd. ACM Inter. Computing Symposium. Venice, 210-220, 1972.
14. Howell, E.H.: The integrated, computer network system, Proc Inter. Conf on Computer Communications, Washington, 214, 1972.
15. Barber, D.L.A. et al: Operating experience with the NPL Network, Proc ACM Symposium on Computer Networks, IRIA, 145, 1972.
16. [Pouzin, L.: Presentation and major design aspects of the Cyclades computer network](#), to be presented at the Third Data Communications Symposium, 1973.
17. [Barber, D.L.A.: The European Computer Network Project](#), Proc. Inter. Conf. on Computer Communications, Washington, 192, 1972.
18. Ornstein, S.M. et al: The Terminal IMP for the ARPA network, SJCC, 40, 243, 1972.
19. [Tymnes, L.R.: TYMNET - A terminal oriented communications network, SJCC, 34, 211, 1971.](#)